UpTempO Buoys for Understanding and Prediction

Michael Steele
Polar Science Center, Applied Physics Lab
Univ of Washington
1013 NE 40th St.
Seattle, WA 98105
phone: (206) 543-6586 fax: (206) 616-3142 email: mas@apl.washington.edu

Award Number: N00014-12-1-0224
http://psc.apl.washington.edu/UpTempO

LONG-TERM GOALS

The overall goal of the UpTempO (= Upper Temperature of the Polar Oceans) project is to better map and explain the variations in the amount of heat in the upper oceans of the polar regions. Time scales of interest span the diurnal to interannual; spatial scales are generally synoptic. Meeting this goal will help in the understanding of the evolving sea ice pack as well as changes in lower atmospheric structure, marine and coastal ecosystems.

OBJECTIVES

- Adapt existing air-deployed thermistor chain buoys for use in the arctic seas.
- Fill a crucial gap in the current UpTempO program by deploying UpTempO buoys from aircraft in poorly sampled areas of the Beaufort and Chukchi Seas.
- Integrate UpTempO buoy data with other data as part of the umbrella SIZRS = Seasonal Ice Zone Reconnaissance Surveys project to better understand air/sea/ice seasonal evolution in this region.

APPROACH

Much of our effort this year was spent communicating with two groups: (i) buoy manufacturers and (ii) Alaskan Coast Guard officials. With regard to buoy manufacturers, our original idea was to work with the company that made our 2011 ship-deployed buoys, MetOcean Data Systems of Dartmouth, NS, Canada. This proved infeasible owing to ongoing development and changes in the design of their version of the buoy, in addition to their relative inexperience with air deployment. We thus chose to work instead with Pacific Gyre Inc. of Oceanside, CA. Pacific Gyre (PG) has the most experience with air-deployed thermistor chain buoys, which have been dropped in front of hurricanes in the Gulf of Mexico. However, new orders for this activity have abated in recent years owing to a backlog of stockpiled buoys. We turned this to our advantage by asking PG to re-design the buoy using new, higher-quality temperature and pressure sensors. For our initial deployments, our buoys have the following sensors, all sampling hourly:

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2012	**N/A**	**-**

4. TITLE AND SUBTITLE	
UpTempO Buoys for Understanding and Prediction	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Polar Science Center, Applied Physics Lab Univ of Washington 1013 NE 40th St. Seattle, WA 98105**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

- Sea level pressure (+/- 1 mbar)
- 13 thermistors at the following nominal depths (m): 0.05 (“SST”), 2.5, 5, 7.5, 10, 15, 20, 25, 30, 35, 40, 50, and 60 (+/- 0.05 degC)
- Ocean pressure sensors at 20 m and 60 m (+/- 1 dbar)

Ocean data are communicated to the surface unit (14 inch diameter spherical ABS plastic hull) via inductive modem. Additionally, the buoy samples GPS location every 3 hours. Communications are via Iridium. The alkaline battery pack is designed to last for 1.5 years.

WORK COMPLETED

- Steele attended the AGU Ocean Sciences Meeting in Salt Lake City (Feb, 2012):
    - Met with Mr. Andy Sybrandy, CEO of Pacific Gyre to discuss buoy design
    - Gave a talk about UpTempO in a session on sea surface temperature.
- Steele met again with Mr. Sybrandy in Seattle to discuss buoy design and manufacture, summer 2012.
- Over the summer 2012, Steele and Sybrandy prepared several versions of buoy documentation for use by the Coast Guard in their ACCB (= Aircraft Configuration Control Board) approval process.
- Two buoys were shipped to Kodiak, AK for potential deployment in late August by the AK Coast Guard C130 as part of the SIZRS program. Unfortunately official approval was not forthcoming at that time, so the buoys were put into storage at the Coast Guard base. In September, Mr. Sybrandy and a PG engineer flew to Kodiak to install batteries and make final preparations for deployment (**Figure 1**). At this time, we await approval for deployment of our buoys. In response to Coast Guard concerns, these buoys were designed to start transmitting (via Iridium) only once they are deployed in the ocean (their magnetic switches fall off in the water). This means they have no impact on flight operations/electronics/communications. We had hoped this would speed the approval process, but (alas) this proved not to be the case. We are optimistic that approval will happen over the winter of 2012/2013. In this case we will deploy our first buoys of the year in early summer, probably May or June 2013.
- Steele traveled to Boulder, CO to confer with colleagues (G. Wick, S. Castro, W. Emery) on various issues related to Sea Surface Temperature (SST) data interpretation and processing. We also had preliminary discussions related to creation of DUAT = Database of Upper Arctic ocean Temperatures, i.e., how to blend data from various sensors/platforms taking data at various depths.
- Steele examined satellite data and some in situ buoy data to better understand recent upper ocean temperature change (Proshutinsky et al., 2012; NSIDC’s “sea ice news” page: http://nsidc.org/arcticseaicenews/2012/09/arctic-sea-ice-falls-below-4-million-square-kilometers/; and NOAA’s 2012 “State of the Arctic” report (Timmermans et al., 2012).

Figure 1. Buoy preparation at the Alaskan CG station in Kodiak. (a) UpTempO buoy in air-deployable cardboard box. Visible is the thermistor cable (black) with thermistor housings (white, in pink bubble wrap). A. Sybrandy of PG is holding a thermstor housing. (b) Thermistors laid out and ready for battery insertion. (c) The two buoys packed for deployment with parachutes (on top) and straps (gray). The straps hold the cardboard box against the palette. (d) salt block at the end of a parachute strap; when this dissolves in the ocean, the straps and outer box fall away from the buoy as it releases the thermistor string into the water.

RESULTS

Science results have been limited by delay of buoy deployment. However, to get started, we have been analyzing ship-deployed UpTempO buoys in the context of the tremendous sea ice retreat in 2012. **Figure 2a** shows the first buoy of the 2012 season, deployed on August 8 by the Canadian icebreaker Louis St. Laurent. This buoy was made by MetOcean Data Systems using some similar technology to the SIZRS buoys to be deployed by aircraft.

Buoy data (**Figure 2b**) indicate two regimes in surface conditions in this area. Initial readings indicate a surface isothermal layer of about 8 degC extending to 10 m depth, with cooler water below. These data were taken near the end of a well-publicized large storm in the area, which at this location caused mixing of the water that had warmed throughout the early/mid summer owing to early sea ice retreat. After a few days, the ocean enters the alternate state, with cooler, more stratified conditions that gradually warm. Around day 235 we're back to well-mixed conditions for a couple of days, followed by the cooler, more stratified regime. So what's going on? To answer this question, we are working with co-SIZRS scientist Dr. A. Schweiger to investigate the meteorological forcing.

Figure 2c shows output from the regional meteorological model (WRF) run by Dr. Schweiger and Dr. R. Lindsay. In his SIZRS annual report, Dr. Schweiger discusses the role of wind direction in creating differences between upper ocean temperature (at 2.5 m depth, green) and the 2 m air temperature (red), both recorded by this buoy. Here we have plotted an additional quantity from the model, wind speed (pink), which determines upper ocean mixing in this area (tidal mixing is very small in the Beaufort Sea). The traditional 5 m/s threshold for significant mixing and diurnal warming is also shown. Broadly speaking, a comparison of Figures 2 and 3 indicates that surface isothermal layers are well-correlated with times of high winds, while stratified conditions appear when winds are lighter. The correlation is not perfect, however, which is partly the result of the Lagrangian nature of drifter data (which can at times represent movement of the buoy into a different spatial regime). Further analysis on this subject is planned for the coming year.

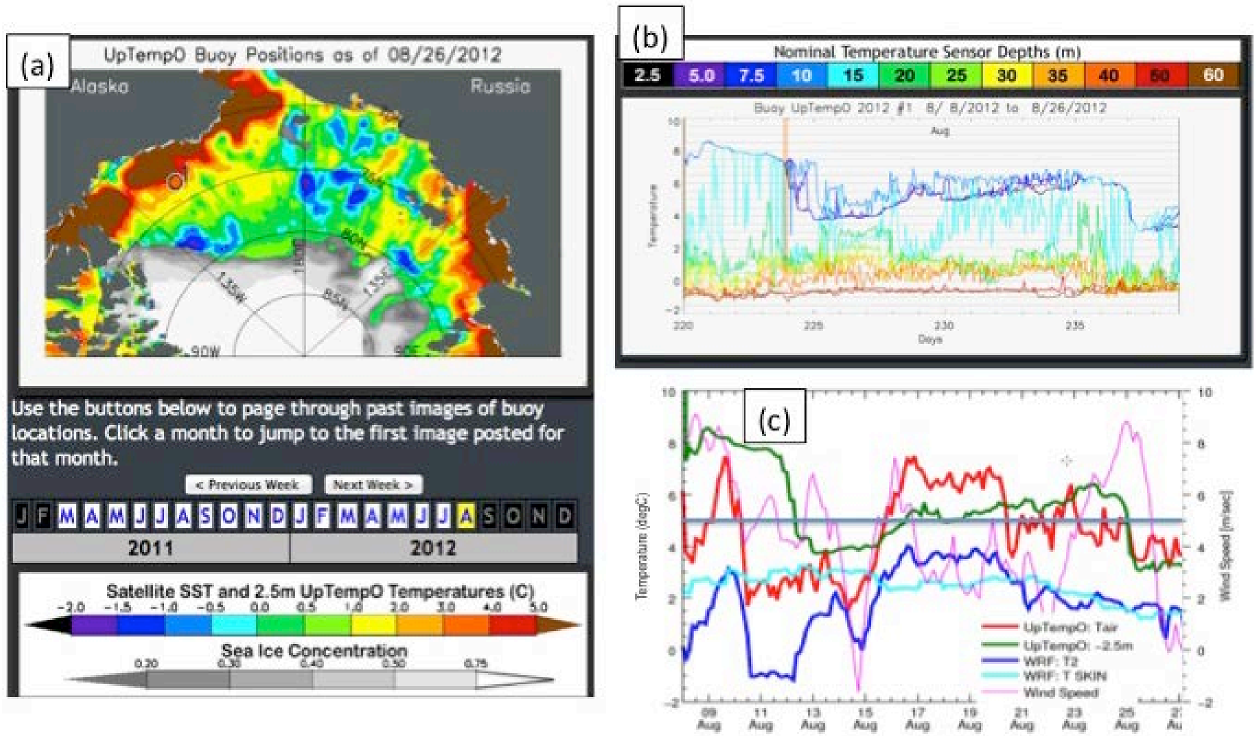

Figure 2. Preliminary UpTempO buoy analysis for summer 2012. (a) Satellite-derived Sea Surface Temperature (SST) field on August 26, 2012, also showing the uppermost thermistor value from an UpTempO buoy (red dot) on the same scale. (b) Time series from this buoy during August. (c) UpTempO and the regional atmospheric model WRF time series following the buoy.

IMPACT/APPLICATIONS

In situ observations are crucial for calibration of satellite-derived SST fields, especially in regions with sea ice where arbitrary assumptions concerning SST in the Marginal Ice Zone are often made. Further, to understand changes in SST, analysis of both meterological and sub-surface ocean temperatures are critical. Thus the UpTempO buoy provides crucial information to understand the ongoing changes in the Arctic Ocean. In particular, for this project we are developing an air-craft deployable version of this buoy which will provide needed flexibility to place buoys in data-poor regions (both in space and in time, i.e. in seasons where icebreakers generally cannot travel).

TRANSITIONS

Many government agencies (and, possibly, private concerns like oil companies) are interested in ocean surface temperature in this region. We are just at the beginning of our project, but we anticipate much interest from operational concerns like NOAA and possibly oil companies.

RELATED PROJECTS

- *Morison* (PI). SIZRS Coordination (ONR-Core)
- *Morison* (PI). Ocean Profile Measurements During the SIZRS (ONR Core)
- *Schweiger* (PI). Atmospheric Profiles, Clouds, and the Evolution of Sea Ice Cover in the Beaufort and Chukchi Seas; Atmospheric Observations and Modeling as Part of the Seasonal Ice Zone Reconnaissance Surveys (ONR-Core)
- *Lindsay* (PI). Visible and Thermal Images of Sea Ice and Open Water from the Coast Guard Arctic Domain Awareness Flights (ONR-Core)
- *Rigor* (PI). International Arctic Buoy Program (ONR-Core)
- *Zhang* (PI). MIZMAS: Modeling the Evolution of Ice Thickness and Floe Size Distributions in the Marginal Ice Zone of the Chukchi and Beaufort Sea (ONR, MIZ DRI)

PUBLICATIONS

Proshutinsky, A., M.-L. Timmermans, I. Ashik, A. Beszczynska-Moeller, E. Carmack, I. Frolov, R. Ingvaldsen, M. Itoh, T. Kikuchi, R. Krishfield, H. Loeng, F. McLaughlin, S. Nishino, R. Pickart, B. Rabe, B. Rudels, I. Semiletov, U. Schauer, N. Shakhova, K. Shimada, V. Sokolov, M. Steele, J. Toole, T. Weingartner, W. Williams, R. Woodgate, M. Yamamoto-Kawai, and S. Zimmermann, The Arctic, c. Ocean [in "State of the Climate in 2011"], *Bull. Amer. Meteor. Soc., 93(7), S143-147*, **2012**.

Timmermans, M.-L., A. Proshutinsky, I. Ashik, A. Beszczynska-Moeller, E. Carmack, I. Frolov, R. Ingvaldsen, M. Itoh, J. Jackson, Y. Kawaguchi, T. Kikuchi, R. Krishfield, F. McLaughlin, H. Loeng, S. Nishino, R. Pickart, B. Rabe, B. Rudels, I. Semiletov, U. Schauer, N. Shakhova, K. Shimada, V. Sokolov, M. Steele, J. Toole, T. Weingartner, W. Williams, R. Woodgate, M. Yamamoto-Kawai, and S. Zimmermann, *NOAA Arctic Report Card: Update for 2012 (Ocean), in review*, **2012**.